Spray pyrolysis deposition of cadmium–zinc oxide thin films

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Abstract

Mixed thin film oxides of cadmium and zinc with different compositions were deposited on glass substrates by spray pyrolysis. The effect of the various parameters on the growth and on the film properties is presented. The sample structure was studied by X-ray diffraction (XRD) having found the presence of a cubic phase resembling that of pure CdO XRD pattern for low Zn concentrations. For \( x = 0.75 \) a low crystallinity of the ZnO structure was observed. Optical band-gap was also studied from optical transmittance measurements. As expected, the band-gap values change between those of pure CdO and those of ZnO.

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1. Introduction

Transparent conducting oxides (TCO) have found extensive application in devices such as liquid crystal displays, transducers and solar cells. In particular, CdO and ZnO are promising materials for solar cells application. These materials have high transparency in the visible and near infrared region of the electromagnetic spectrum and both materials show \( n \)-type conductivity. The electrical conductivity in the films is mainly due to oxygen deficiency. CdO thin films have a band-gap which shifts from 2.3 to 2.7 eV with increasing carrier concentration [1], and therefore can be obtained with a relative low resistivity while undoped ZnO thin films, with optical gap about 3.2 eV, present high values of resistivity. Hence, the properties of these mixed thin film semiconductor oxides must be between the extreme values of (CdO) and (ZnO). (CdO)\textsubscript{1−x}(ZnO)\textsubscript{x} mixed thin films oxides have been attempted before using a sol-gel technique [2]. Spray pyrolysis is a simple and economic technique and can be adapted for the production of large-area films. Both CdO and ZnO thin films have been obtained by spray pyrolysis [3,4]. The aim of this work is to report the preliminar properties of mixed thin film oxides grown by the spray pyrolysis method.

2. Experimental

(CdO)\textsubscript{1−x}(ZnO) films were grown on glass, using a typical spray pyrolysis apparatus. The spray solution was prepared by mixing the appropriate volumes of cadmium acetate (0.1 M) and zinc acetate (0.1 M) dissolved in a mixture of methanol and deionized water (1:1). The substrate temperature was varied in the range 200–300°C and was controlled within \( \pm 5 \)°C through a thermocouple (chromel–alumel) as a sensor for the temperature controller. The solution flow rate and gas pressure was kept constant at 5 ml/min, and \( 5 \times 10^4 \) kg/m\textsuperscript{2}, respectively. \( N_2 \) was used as the carrier gas. The nozzle to substrate distance was 0.25 m. The spraying time was varied in the interval 4–15 min. The layer thickness was measured using a step profligner (Sloan Dektal II). Optical transmission data were obtained with an UV–visible Shimadzu 3101 PC double bean spectrophotometer. The X-ray diffraction patterns were obtained by means of a D-500 Siemens X-ray system using the Cu K\textsubscript{a} line. For the study of the influence of post-thermal annealing, one composition \( x = 0.5 \) was annealed at 450°C for 1 h in air.

3. Results

Fig. 1 shows the variation of the film thickness with deposition time for different compositions \( x \) in the solution. The film thickness increases linearly with deposition time for all compositions \( x \) investigated. As can be seen, the intersections of the curves with the time axis do not cross...